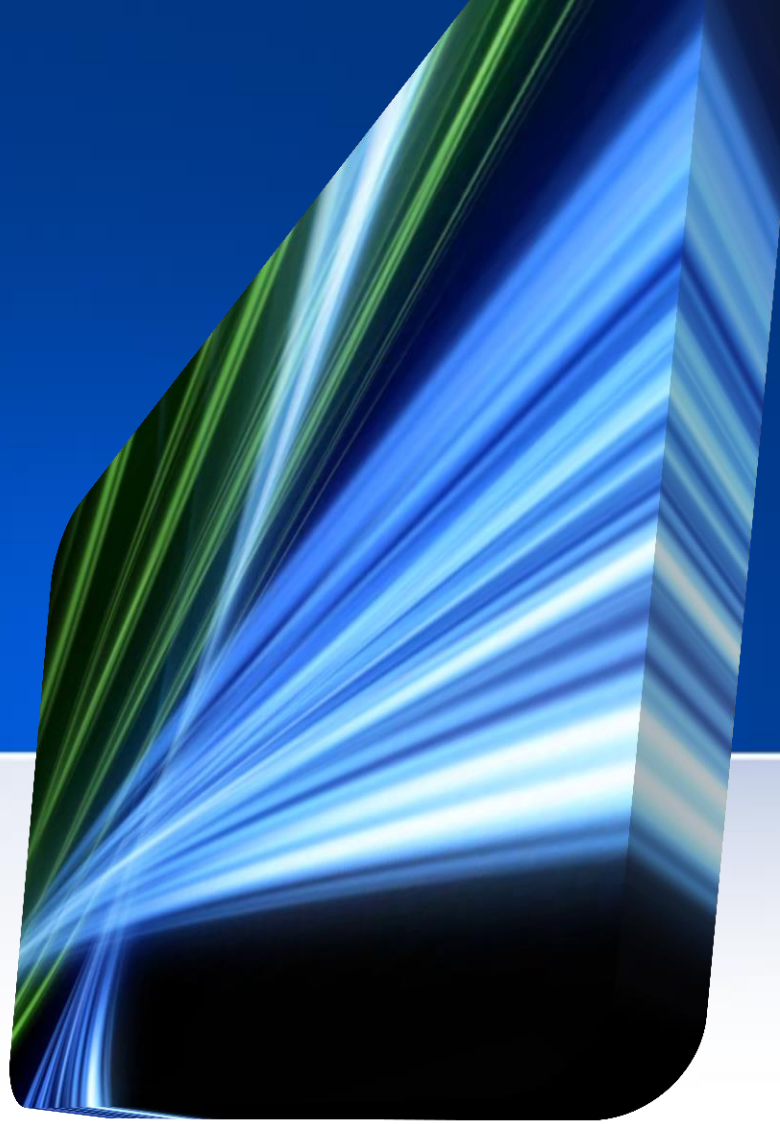
Ch. 1

Feedback Amplifiers



Dr. Mohamed Salah

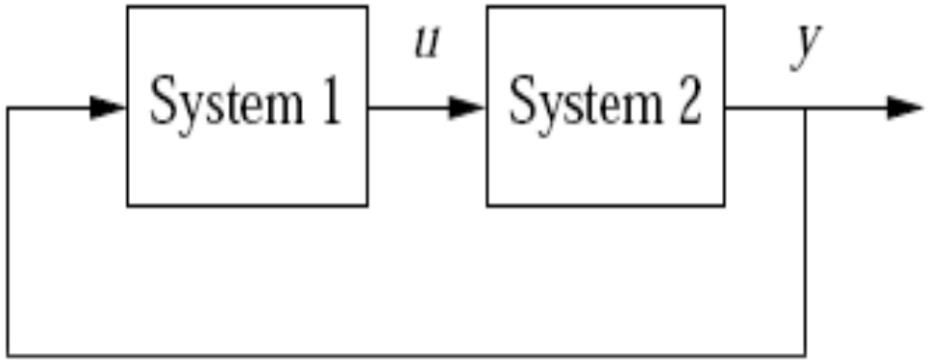
1- What is Feedback?

- The process in which the effect or output of an action is 'returned' (feed-back) to modify the next action.

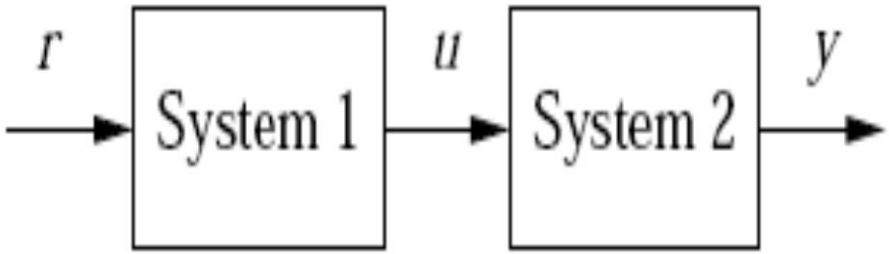
- In an organizational context, feedback is the information sent to an entity (individual or a group) about its prior behavior so that the entity may adjust its current and future behavior to achieve the desired result.

1- What is Feedback?

(a) Closed Loop



(b) Open Loop



A closed loop systems uses a measurement of the output signal and a comparison with the desired output to generate an error signal that is applied to the input.

An open loop (direct) system operates without feedback and directly generates the output in response to an input signal.

2- Advantages of Feedback

1. It can make a system resilient toward external influences.
2. It can also be used to create linear behavior out of nonlinear components, a common approach in electronics.
3. It allows a system to be insensitive both to external disturbances and to variations in its individual elements.
4. Decreased sensitivity of the system to variations in the parameter of the process
5. Improved measurement noise attenuation
6. Improved reduction of the steady-state error of the system
7. Easy control and adjustment of the transient response of the system

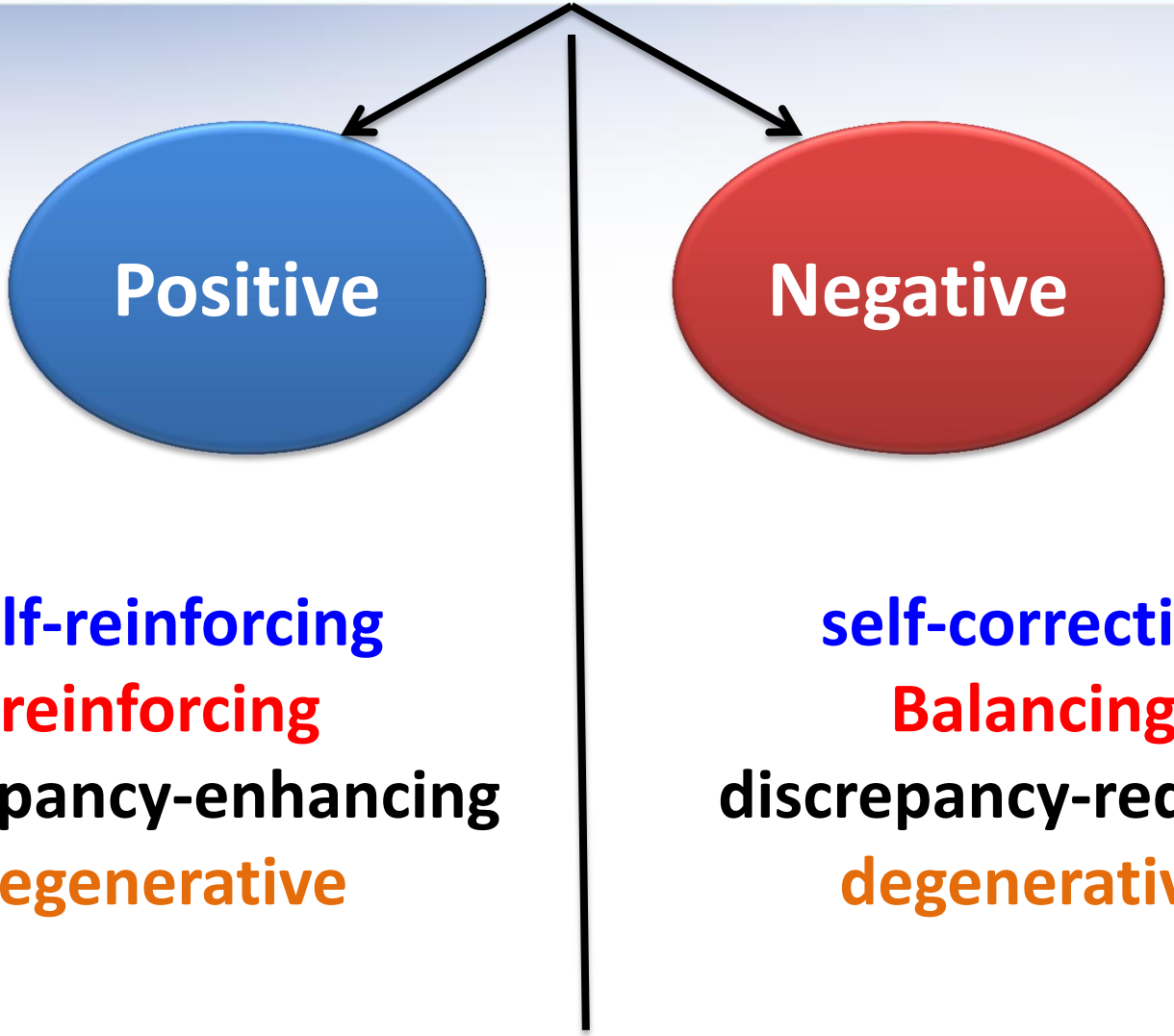
3- Disadvantages of Feedback

1. It can create dynamic instabilities in a system, causing oscillations or even runaway behavior.
2. It can introduce unwanted sensor noise into the system, requiring careful filtering of signals. (we have to measure it)
3. Complexity and high cost.

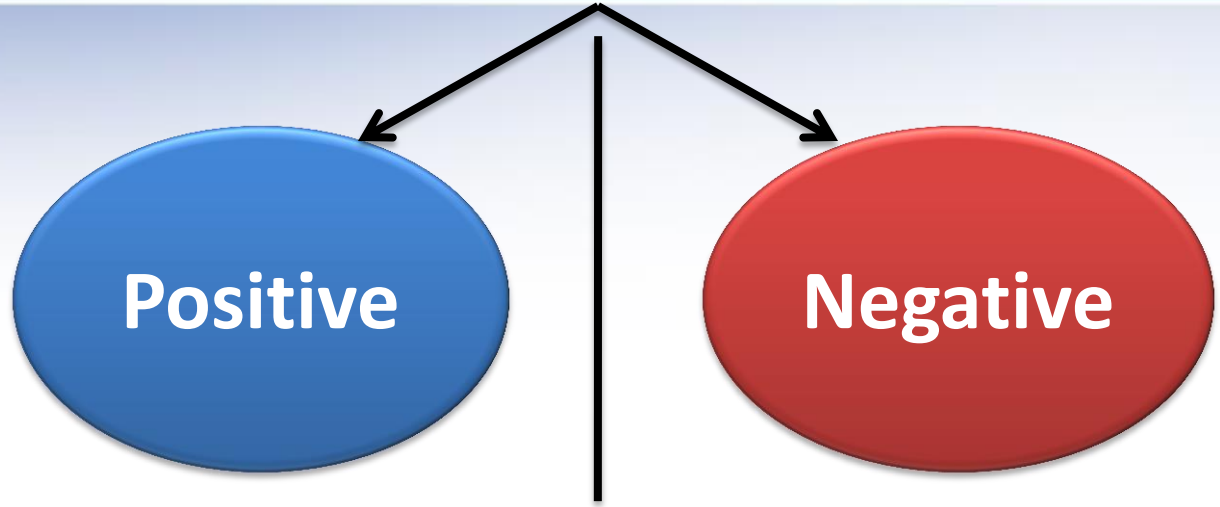
Clarify

Feedback systems are ubiquitous in both natural and engineered systems.

4- Types of Feedback



4- Types of Feedback



1- the gap between reference and actual values of a parameter, based on whether the gap is widening (positive) or narrowing (negative),

2- the action or effect that alters the gap, based on whether it has a positive or negative emotional connotation to the recipient or observer.

4- Types of Feedback

Negative

1. When the feedback output signal is out of phase with the input signal.
2. Introduced to increase the stability and accuracy of a system by correcting unwanted changes.
3. This scheme can fail if the input changes faster than the system can respond to it.
4. When this happens, the lag in arrival of the correcting signal can result in over-correction, causing the output to oscillate or "hunt“.

4- Types of Feedback

Positive

1. When the feedback signal is in phase with the input signal.
2. Under certain gain conditions, positive feedback reinforces the input signal to the point where the output of the device oscillates between its maximum and minimum possible states.
3. Positive feedback may also introduce hysteresis into a circuit, so it ignores the small signals and respond only to large ones. (to eliminate noise from a digital signal).
4. Under some circumstances, positive feedback may cause a device to latch. (Saturation)

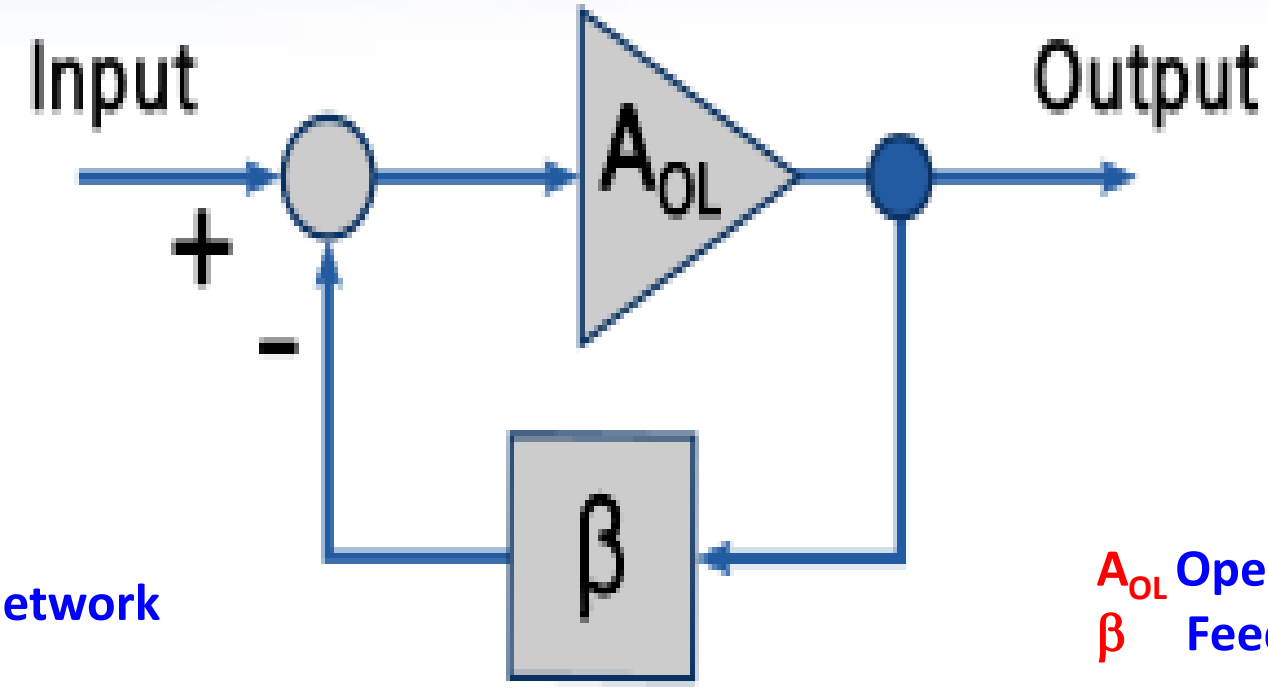
5- Negative Feedback Amplifier

Or feedback amplifier

1. **Combines a fraction of the output with the input so that a negative feedback opposes the original signal.**
2. **Improves performance (gain stability, linearity, frequency response, step response) and reduces sensitivity to parameter variations due to manufacturing or environment.**
3. **Because of these advantages, negative feedback is used in this way in many amplifiers and control systems.**

5- Negative Feedback Amplifier

Or feedback amplifier



Amplifier
Feedback Network
Subtractor

A_{OL} **Open loop gain**
β **Feedback factor**

Figure 1.2 Ideal negative feedback model.

5- Negative Feedback Amplifier

- Can increase or decrease input impedance and output impedance (depending on type of feedback)
- Reduces distortion (increases linearity)
- Increases the bandwidth
- Desensitizes gain to component variations
- Can control step response of amplifier

- May lead to instability if not designed carefully
- The gain of the amplifier decreases

5- Negative Feedback Amplifier

Gain reduction

$$V_{out} = A_{OL} \cdot V'_{in}$$

$$V'_{in} = V_{in} - \beta \cdot V_{out}$$

$0 \le \beta \le 1$

$$V_{out} = A_{OL}(V_{in} - \beta \cdot V_{out})$$

- $A_{OL} >> 1$
- $\beta A_{OL} = -1$

$$V_{out}(1 + \beta \cdot A_{OL}) = V_{in} \cdot A_{OL}$$

closed-loop gain or feedback gain

$$A_{fb} = \frac{V_{out}}{V_{in}} = \frac{A_{OL}}{1 + \beta \cdot A_{OL}}$$

5- Negative Feedback Amplifier

β

1. For an operational amplifier two resistors forming a voltage divider may be used for the feedback network to set *β* between 0 and 1.
2. This network may be modified using reactive elements like capacitors or inductors to:
   (a) give frequency-dependent closed-loop gain as in equalization/tone-control circuits or
   (b) construct oscillators.

5- Negative Feedback Amplifier

loop gain $\beta \cdot A_{OL} \longrightarrow L$

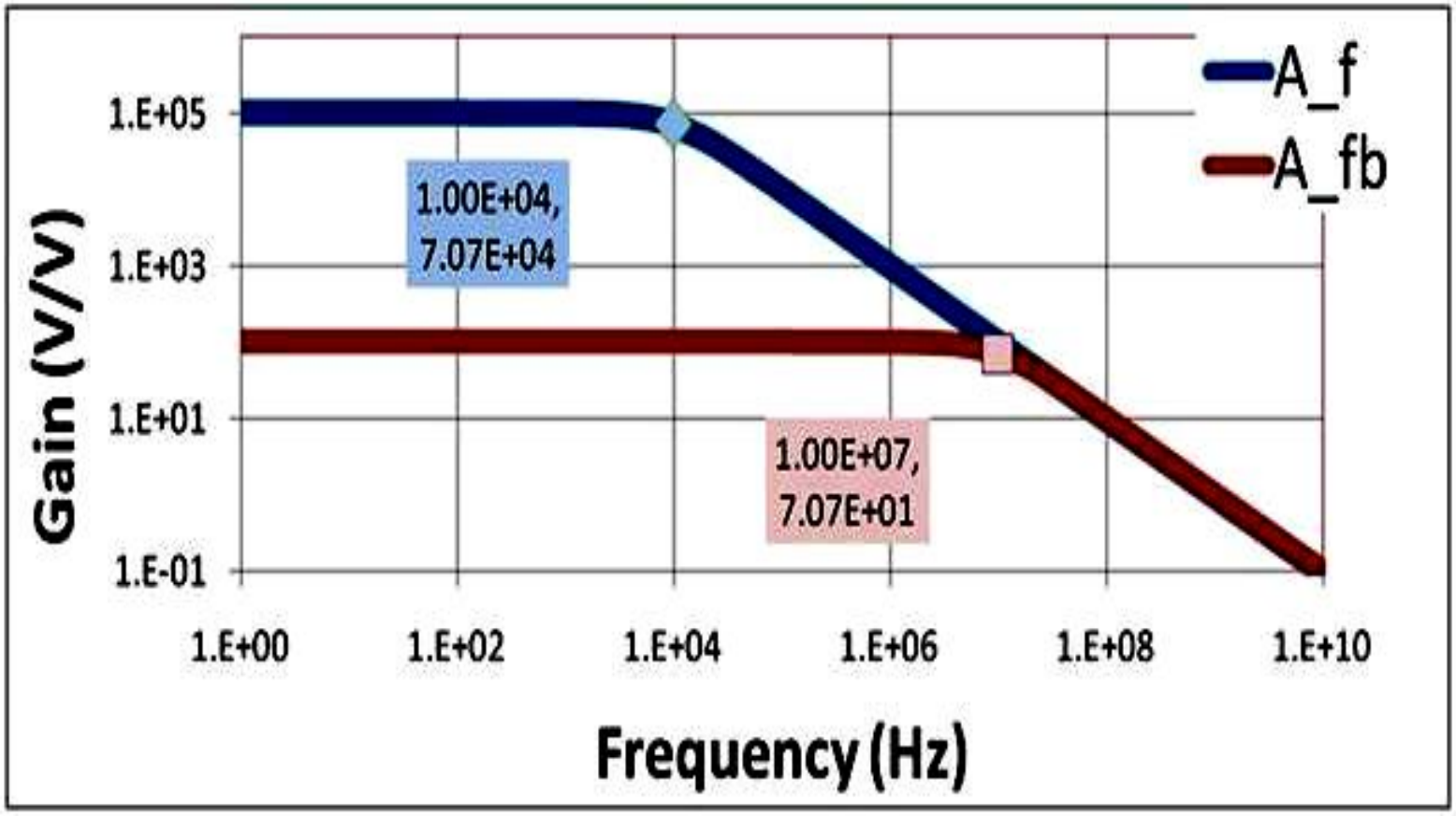
The stability characteristics of the gain feedback product (βA_{OL}) are often displayed and investigated on a Nyquist plot (a polar plot of the gain/phase shift as a parametric function of frequency). A simpler, but less general technique uses Bode plots.

desensitivity factor or the improvement factor $\longrightarrow 1 + \beta \cdot A_{OL}$

5- Negative Feedback Amplifier

Bandwidth extension

Feedback can be used to extend the bandwidth of an amplifier at the cost of lowering the amplifier gain.



Thank You